CHAPTER

11

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BARRIER AND END TREATMENT SYSTEMS

OVERVIEW

Crash tested and approved effective barrier systems, end treatments, and crash cushions, shall be used to achieve the highest levels of highway safety. Any highway safety appurtenance which do not meet the appropriate crash test requirements or are not considered as operational by FHWA and LA DOTD shall not be specified in any plans. This will include all generic as well as proprietary items. Prior to 1994 all highway safety devices were crash tested in accordance with the guide lines outlined in the National Cooperative Research Program 230 (NCHRP230). NCHRP 230 has been replaced by another publication, which is referred to as NCHRP 350 since early 1994. Although many safety appurtenances are crash tested to meet these new criteria, FHWA has not established a target date in which time the NCHRP 350 criteria will become mandatory. This is partially due to the fact that the more stringent criteria in this new document has made it very difficult for some widely used existing devices to pass the crash test. In fact a partial rewrite of NCHPR 350 may be necessary before it is mandated nationwide. Until such date, the NCHPR 230 will remain as the official criteria for approval of safety appurtenances. However, all items which have passed the test under NCHRP 350 shall be given favorable consideration for use on state highways.

Uses of proprietary items are generally not recommended unless a generic equal is not available. When proprietary items are specified, plans shall allow an equal substitute subject to the approval of the department and at no extra cost.

In selecting or working with any type of roadside safety appurtenance, consult the latest issue of AASHTO; Roadside Safety Guide for the Recommended Procedures, and design criteria.

HISTORY OF CRASH TESTING

Procedures for full-scale vehicle crash testing of Roadway Barriers were first published in Highway Research Institute in 1973 to address the questions that were not covered in circular 782. Following this project the first report was published as "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances", NCHRRP Report 153. This 16-page document was based on technical input from more than 70 individuals and agencies as well as extensive deliberation by a special adhoc panel. This report later proved to be inadequate and NCHRP Project 22-2(4) was initiated in 1979 by Southwest Research Institute to address the major changes that had been recommended through a special committee action under TRB Circular 191. The final report of NCHRP Project 22-2(4) was published as NCHRP Report 230 "Recommended Procedures for the Safety Performance Evaluation of Highway Safety Appurtenances", in 1980.

This thirty-six-page document incorporated new procedures, updated the evaluation criteria and brought the procedures up to date with available technology and practices. This document served as the primary reference for full-scale crash testing of highway safety appurtenances in the United States and in many other parts of the world.

In 1987, AASHTO recognized that the evaluation of roadside safety concepts, technology, and practices necessitated an update to report 230. The reason included significant changes in the vehicle fleet, the new policies requiring the use of safety belt and advances in computer simulation and other evaluation methods.

Following this recognition, a team of experts from Texas Transportation Institute (TTI) and Dynatech Engineering began their effort in 1989 toward the creation of a new set of criteria to replace the NCHRP 230. The end result of their effort has been the creation of the NCHRP 350, which represents a comprehensive update of the procedures for safety performance evaluation.

Report 350 differs from report 230 in the following ways:

1. It is presented as all metric documents.

2. It provides a wider range of test procedures to permit safety performance evaluations for a wider range of barriers, terminals, crash cushions, breakaway support structures and utility poles, truck-mounted attenuators, and work zone traffic control devices.

3. It uses a pickup truck as the standard test in place of the 4500-lb. passenger car to reflect the fact that almost 25% of the passenger vehicles on U.S. roads are "light truck" category.

4. It defines other supplemental test vehicles including a mini-compact passenger car (700 kg), single unit cargo trucks (800 kg) and tractor-trailer vehicles (36 000 kg).

5. The three basic evaluation criteria categories remain the same. The occupant risk criteria retains the use of the flail space model, but defines preferred and maximum levels of occupant impact velocity and acceleration.

6. It provides optional criteria, established by others for side impact testing.

LOUISIANA PRACTICE

Barriers

Details of several crash- tested roadway barriers have been shown in this chapter. Among these barriers, the double-face thrie beam and the sloped-face concrete barriers are considered by FHWA as "Innovative Barrier". When required by FHWA, these barriers may be used in lieu of the more conventional type.

Barriers shown here are in two basic categories. First, the permanent barriers second the temporary barriers. Temporary barriers are commonly used in construction zone. When temporary barriers are utilized on bridge structures a positive connection to the bridge deck shall be provided, unless it is determined that a considerable lateral deflection of the barrier system can be tolerated. The blunt ends of temporary barriers shall be made crashworthy by means of either an end treatment device or by flaring away from traffic and carrying beyond the clear zone distance.

Guardrail

Virtually all information pertaining to guardrail is contained in the Standard Plan G.R-200(M). This Standard provides information to the designers for the purpose of determining the "Length of Need" and to the contractors, for the purpose of constructing the guardrail.

In addition to G.R-200(M), Standard Plan G.R-201(M) and G.R-202(M) are provided to aid the designers with specific applications of guardrails. By using these particular standards the designers may show the dimensions which are unique to a specific condition on a simple

Sketch in the contract plans and make reference to a detail on the standard plan to provide the more generic information. Standard plans G.R-201(M) and G.R-202(M) shall always be used in conjunction with Standard Plan G.R-200(M).

Although guardrail standard plans adequately provide the necessary information to construct the guardrail system, it is very important that plans provide all information necessary for the specific site condition. For example, plans shall always show the total length, the length of each pay item, the location, the flare rate, the type of end treatment and any special notes or details.

When bridge construction is considered as "Spot Replacement", often there is little or no road construction, and in such cases minimum guard rail length shall be provided to make the bridge rail blunt ends crashworthy. In these situations, it is not necessary to design "length of need" to provide protection for the full "clear zone" distance behind the bridge rail. An exception to this is when the existing road in the vicinity of the structure provides the design "clear zone" distance, in which case the guardrail for the bridge ends shall provide protection consistent with that "clear zone" distance. The decision whether the minimum length or the standard length is to be utilized shall be made at the Plan-In-Hand

meeting after the road condition is examined. The final decision shall be included in the Plan-In-Hand report. When minimum guardrail lengths are utilized in "spot replacement" conditions, there will be no need for acquiring a design exception.

In all conditions, where the criteria within the standard plans can not be concurred, a design exception from the Chief Engineer shall be obtained and shall be stated in the plans. Statements of such design exceptions will provide easy reference to these exceptions when the department is challenged in litigation. End treatment of bridge railing located outside of the clear zone is recommended unless it is determined not feasible. End treatment of combination traffic and pedestrian railing when curbs and sidewalks are present is not recommended. The standard guardrail end treatment is "Modified Eccentric Loader Terminal" (MELT). This type of end treatment has a parabolic flare and is most suitable for when the line guardrail is flared away from the traffic. When the line guardrail has little or no flare, "MELT" can be used, however, under tight space condition, the placement of a parabolic end treatment may be difficult as well as undesirable. In such cases, a straight end treatment such as ET-2000 or equal may be utilized. When using this type of end treatment the line guardrail may be flared at a rate not to exceed 1:50.

For guardrails on existing roads and bridges see EDSM NO. 11.3.1.3. This EDSM outlines the procedures for guardrail design on existing conditions.

Bridge railing on all detour bridges shall be protected with a crashworthy end treatment. Flexible bridge railing can be adequately protected with a minimum guardrail length of 11 430 mm. However, when rigid barriers such as concrete safety shapes are used an additional 7620 mm transition guardrail section shall be included.

Guardrails for Off-System Projects

The guardrail standard plans applicable to off-system bridge projects are as follows:

GR-203A (M)

GR-203B (M)

BR-05 (M)

All standard plans for off-system projects shall be used in conjunction with Standard Plan GR-200 (M).

GR-203A (M) makes provisions for bridge end treatment on all classifications of off-system projects.

GR-203B (M) provides a shorter guardrail length than GR-203A (M), for when site conditions do not allow the installation of the standard length guardrail contained in GR-203A (M).

BR-05B (M) is a safety shape bridge barrier that is flared down within a 3000 mm length. These standards are applicable for situations where physical conditions do not allow the application of Standard Plans GR-203A (M) and GR-203B (M).

In addition to these standards, Standard Plan GR-200 (M) contains details for bridges near intersections. At the discretion of the Design Engineer, these details may be applied when it is geometrically appropriate.

Crash Cushions (Impact Attenuators)

Crash cushions or impact attenuators are protective devices, which prevent errant vehicles impacting fixed object hazards.

Commonly, impact attenuators are in two categories:

1. Kinetic attenuators

2. Inertial attenuators

Kinetic attenuators are generally referred to as compression crash cushion. This type of attenuator needs a rigid backup wall to resist the impact loads. The kinetic attenuators work based on the absorption of the kinetic energy of a moving vehicle by crushable or plastically deformable materials placed in front of a hazard. Some of the energy is also dissipated by the crushing of the front end of the impacting vehicle.

The inertial attenuators work based on the conservation of momentum principle. The expandable mass usually consists of containers filled with sand or water. There is no need for a back wall. Momentum is equal to the mass of a body multiplied by its velocity. Application of the conservation of the momentum concept will not completely stop the vehicle; however, it will be adequate to reduce the velocity of the vehicle to about 15 km/hr after the last module has been impacted. The use of inertial attenuators such as sand barrel systems is not recommended for gore areas on elevated structures. However, for highway applications they can be effective and economical. Virtually all impact attenuators used in Louisiana are proprietary items. There are a number of proprietary attenuators in the market, most of which are manufactured by "Energy Absorption Systems, Inc.".

The "Hex-Foam Sandwich" is among the most commonly used attenuators in our state. The designer using the manufacturer's design information shall determine its length and width. The construction and the installation of such devices shall always be in accordance with the manufacturer's recommended procedures.

The "Great" is another form of attenuator, which is compatible with "Hex-Foam" both in performance and cost. However, the use of this attenuator is generally reserved for very narrow locations as opposed to the "Hex-Foam" which is available in varying widths.

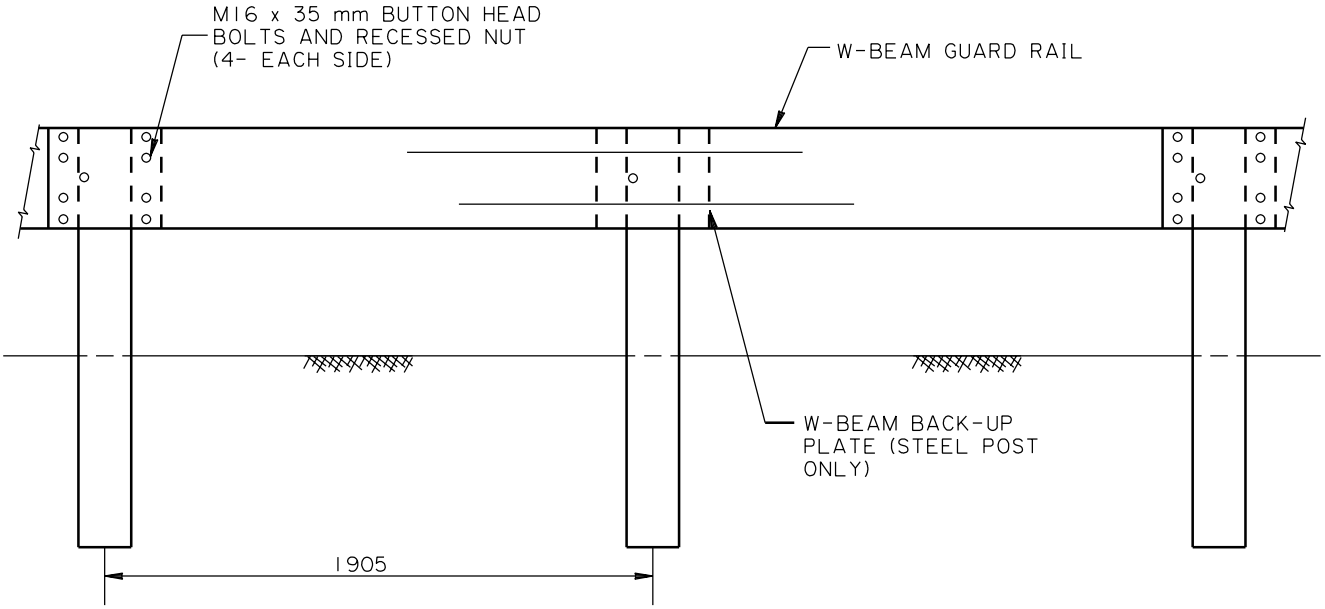
The "Construction Zone Great" is an attenuator commonly used in work zones and the only thing the designer needs to do is to specify its use on the plans.

The design of attenuators shall be in accordance with industry standards. Impact attenuators shall be designed for the maximum average deceleration level not exceeding approximately 7.0 g's.

The reserve area for gores shall be designed and checked in accordance with the latest AASHTO geometric specification. These criteria are also available in the "Roadside Design Guide" under "Crash Cushions".

Although for many years, proprietary attenuators have been the primary source of attenuators, many state DOTs have made considerable progress in designing their own generic attenuator systems. There are many costs saving advantages in such devices, one of which arises from the fact they can be fabricated on a competitive basis.

The Bridge Design Section is working to provide better information regarding the generic attenuators, and as soon as fabrication plans are available, the use of these attenuators will be strongly recommended.



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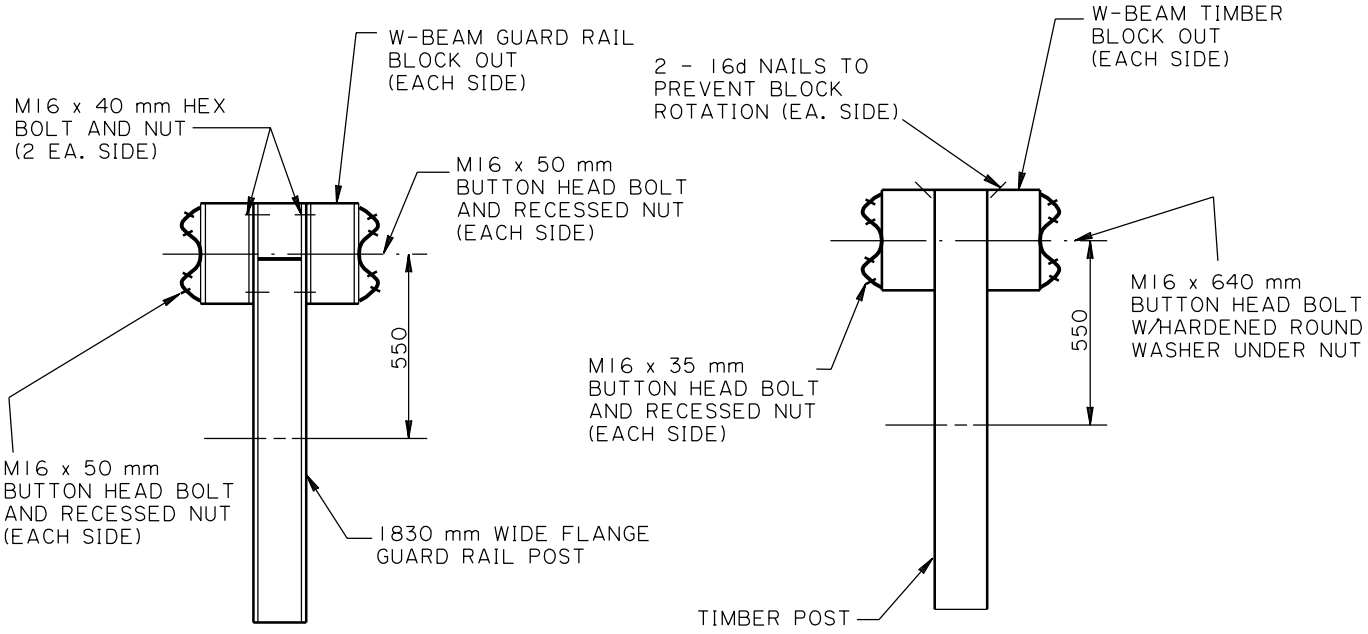
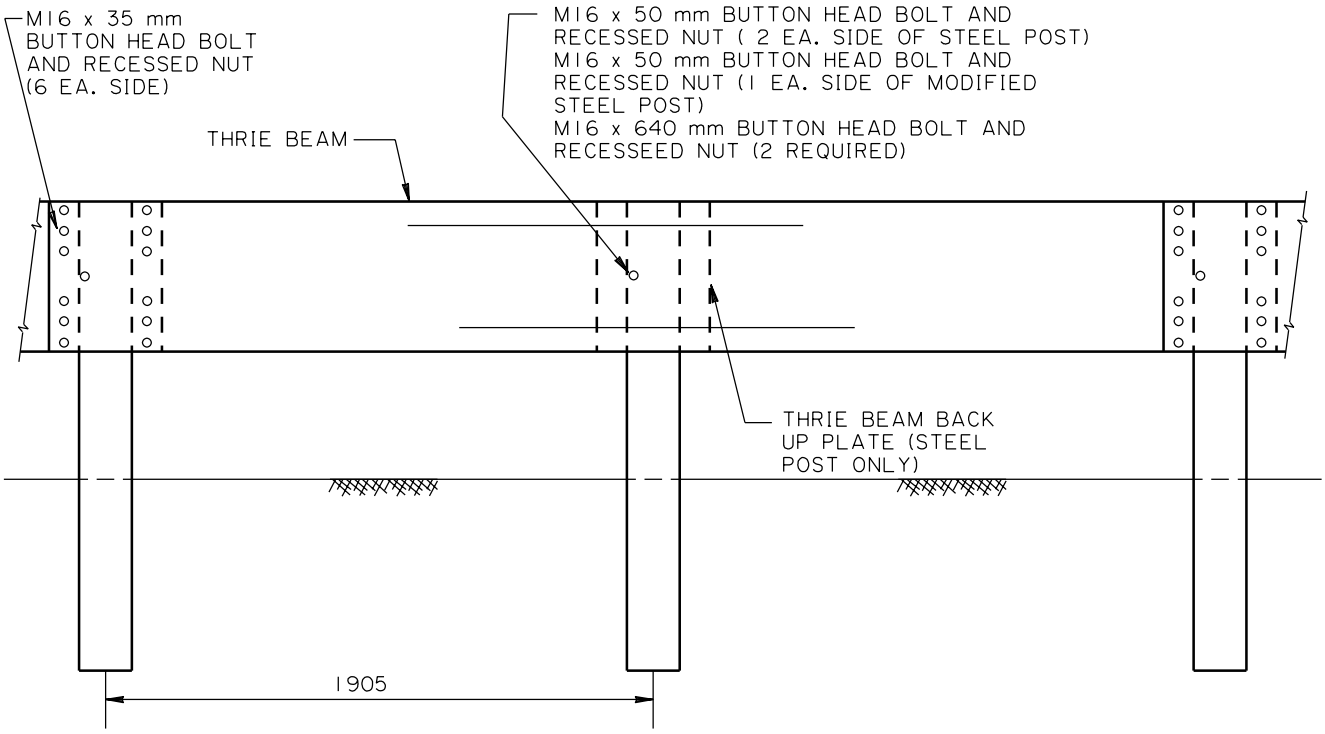


STEEL POST

TIMBER POST

STRONG-POST, W-BEAM MEDIAN BARRIER



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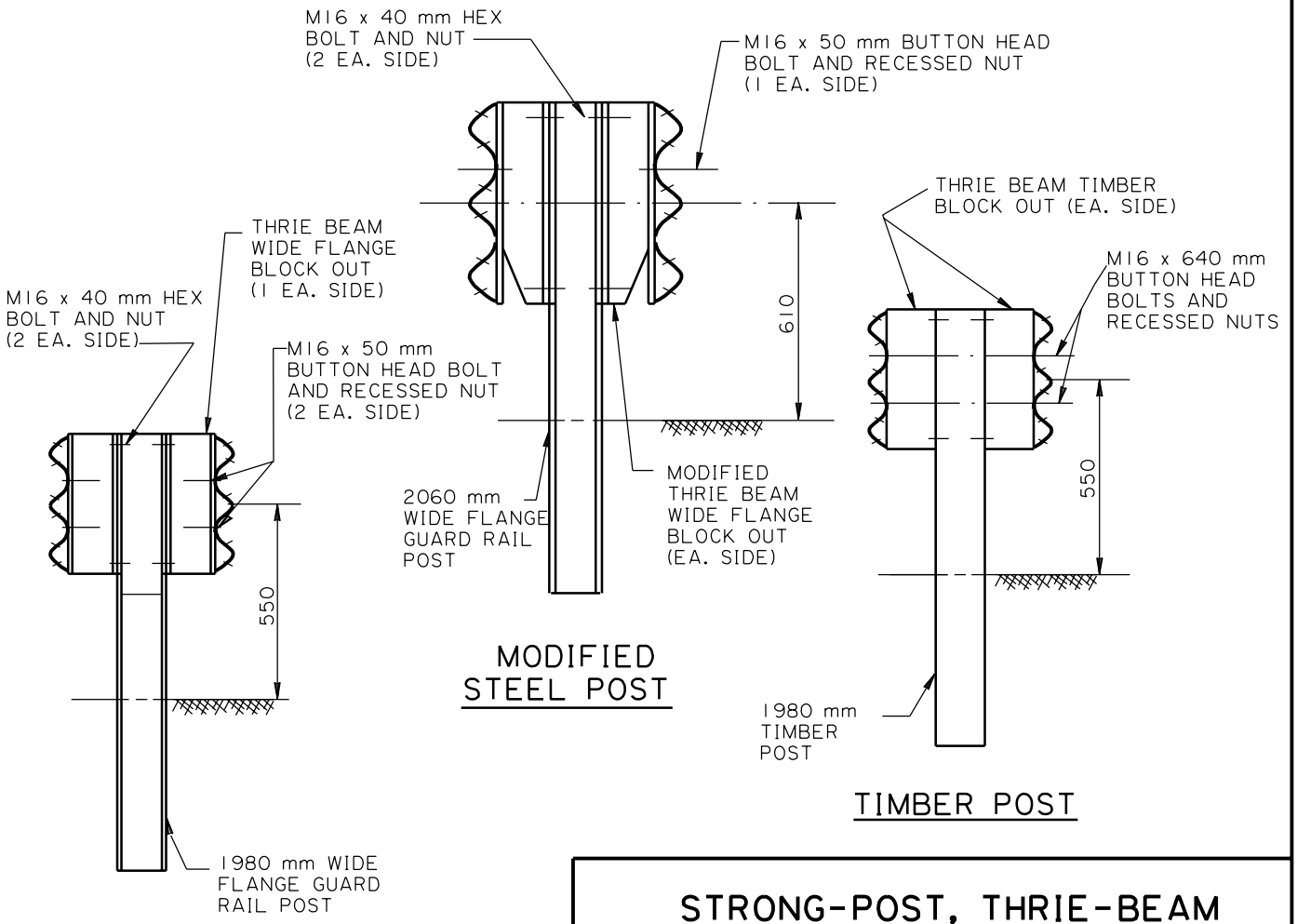


MODIFIED STEEL POST

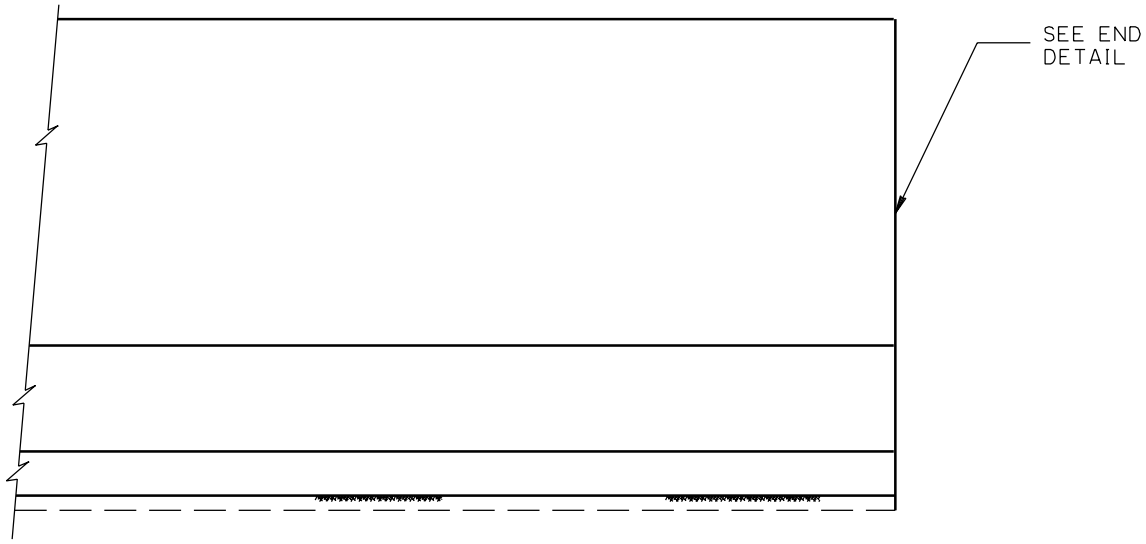
TIMBER POST

STEEL POST

STRONG-POST, THRIE-BEAM MEDIAN BARRIER

NOTES:

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.



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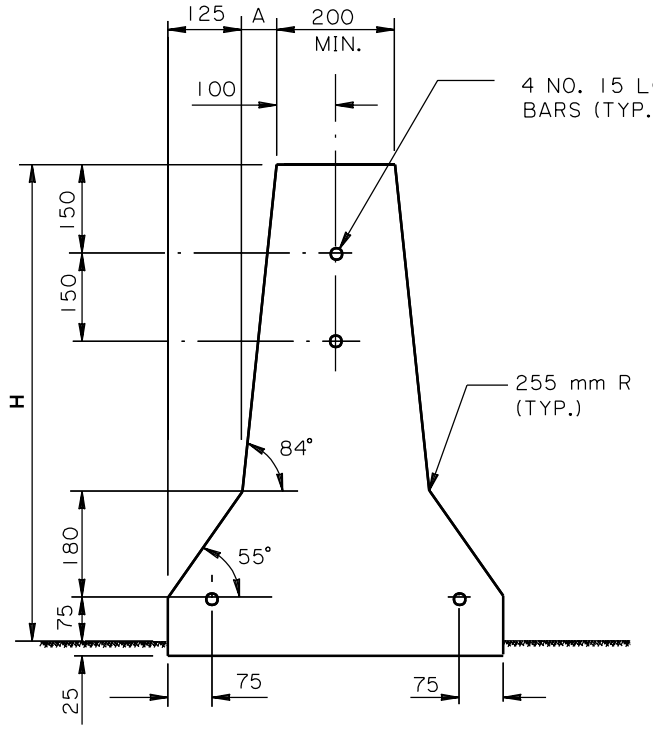

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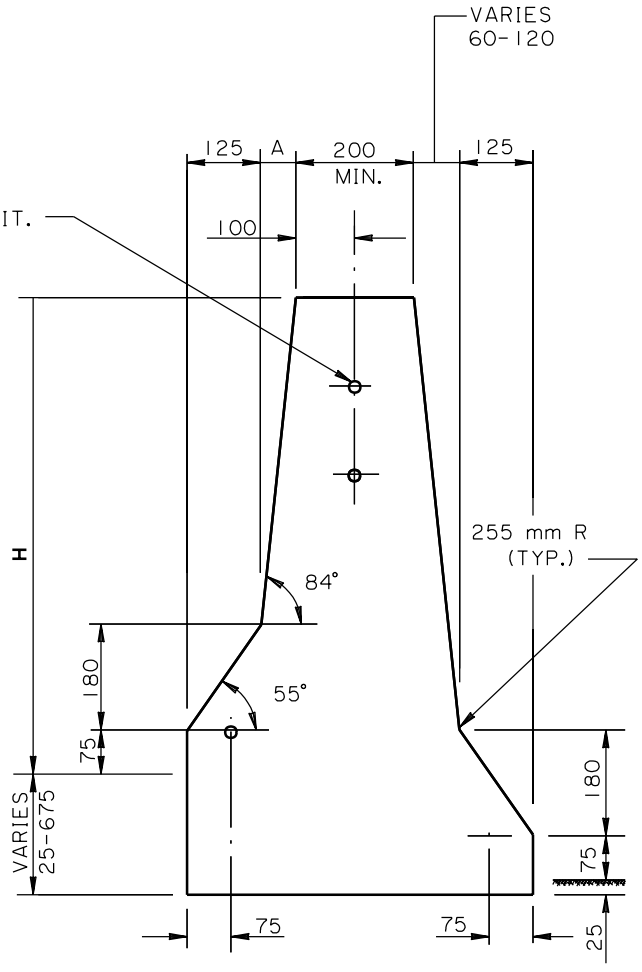


SECTION

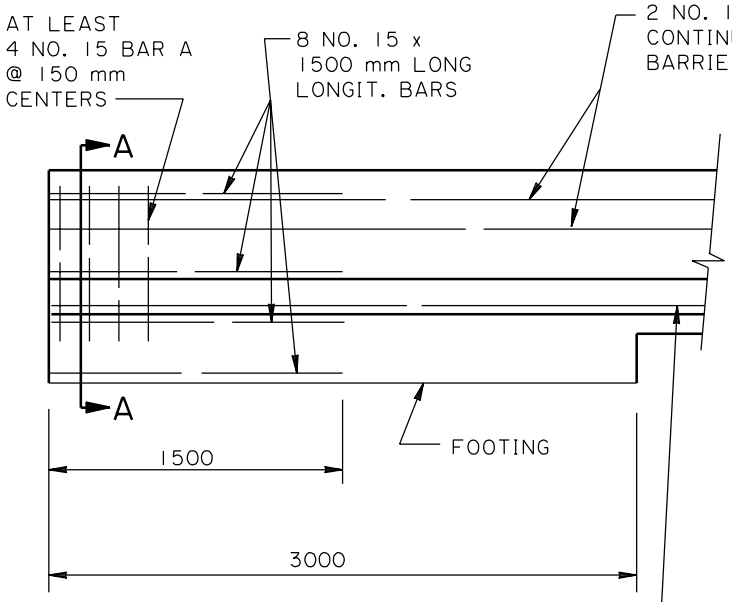
SYSTEM	A	H
F-SHAPE (PL-2)	60	810
F-SHAPE (PL-3)	85	1070

F-SHAPE MEDIAN BARRIER

1 OF 2

NOTES:

1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



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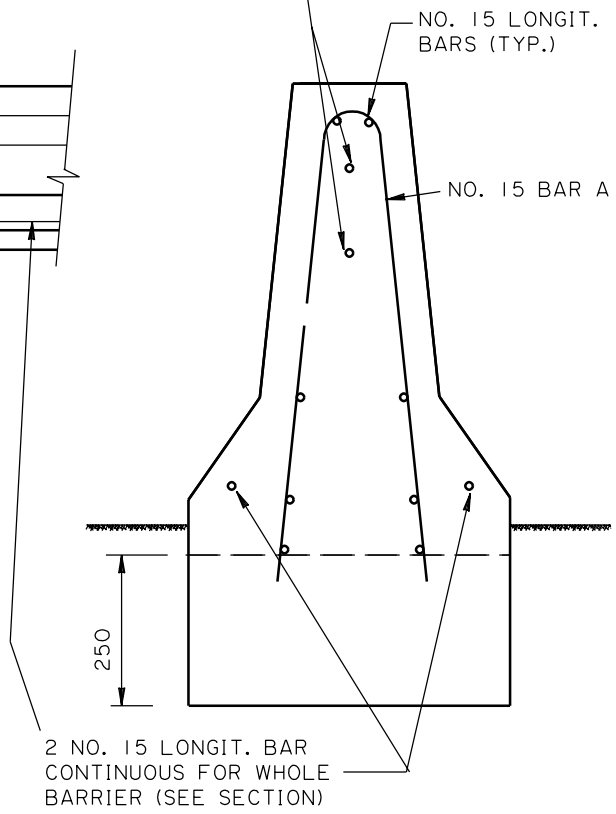
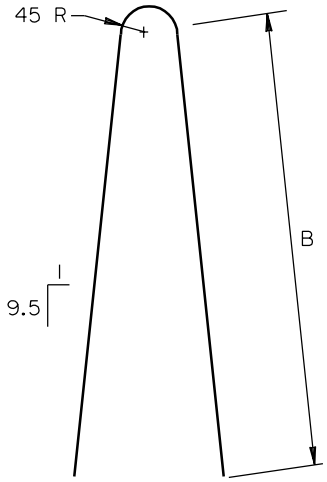


SECTION A-A



BAR A (NO. 15)

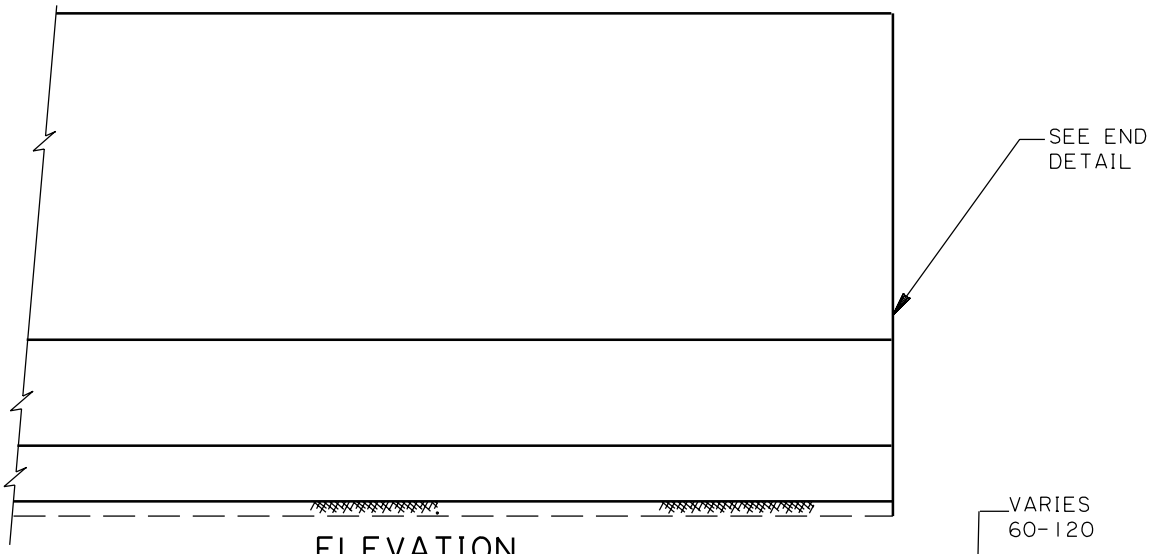
SYSTEM	B
F-SHAPE (PL-2)	910
F-SHAPE (PL-3)	1170

F-SHAPE MEDIAN BARRIER

2 OF 2

NOTES:

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.



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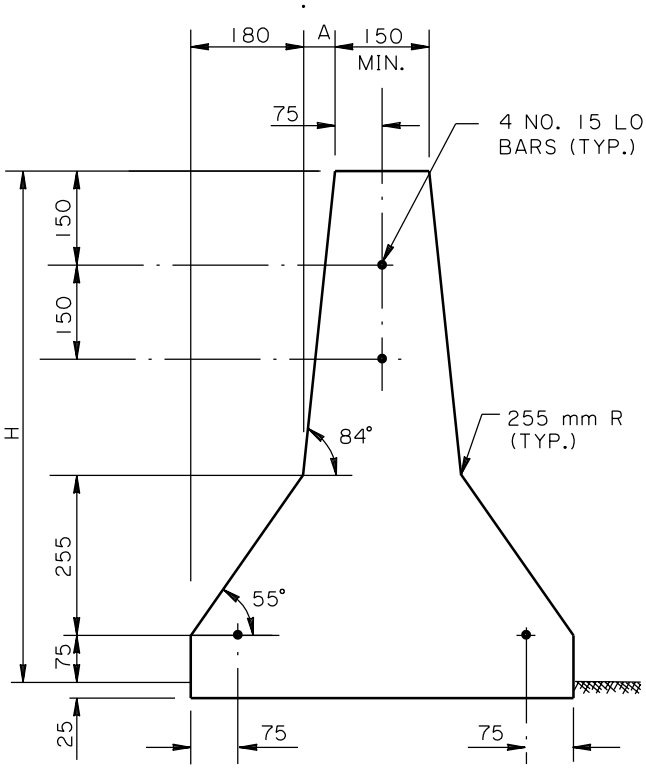

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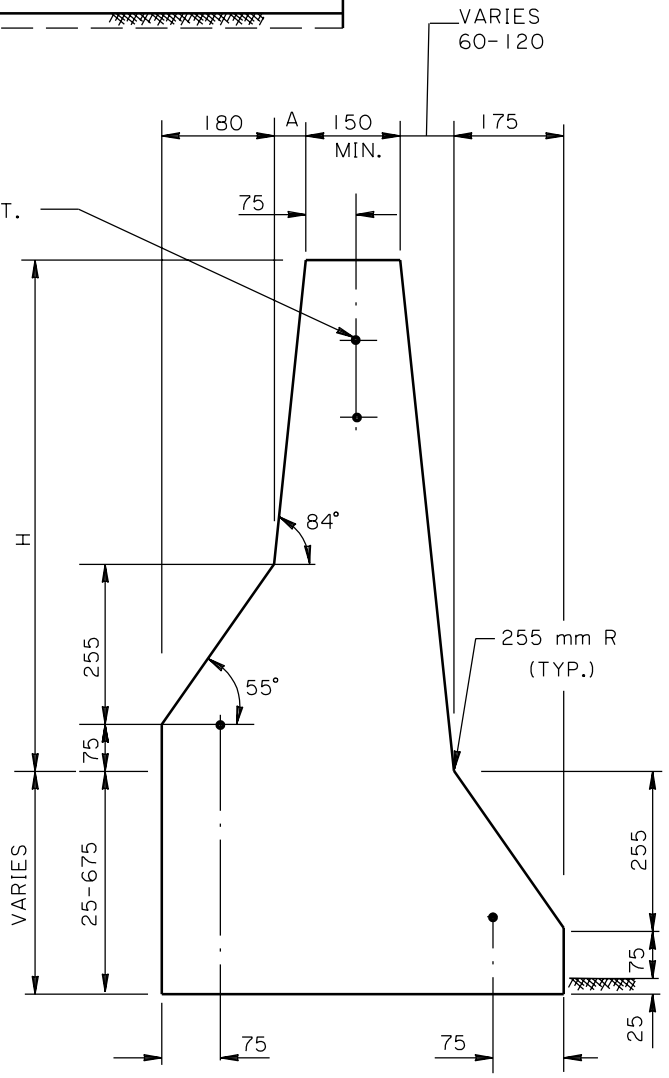


SECTION

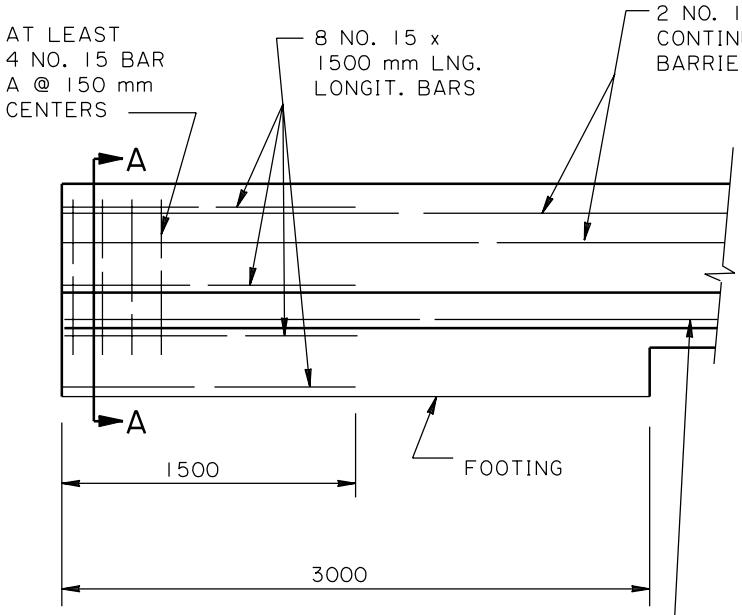
SYSTEM	A	H
N.J. SHAPE (PL-2)	50	810
N.J. SHAPE (PL-3)	80	1070

SAFETY-SHAPE MEDIAN BARRIER

1 OF 2

NOTES:

1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



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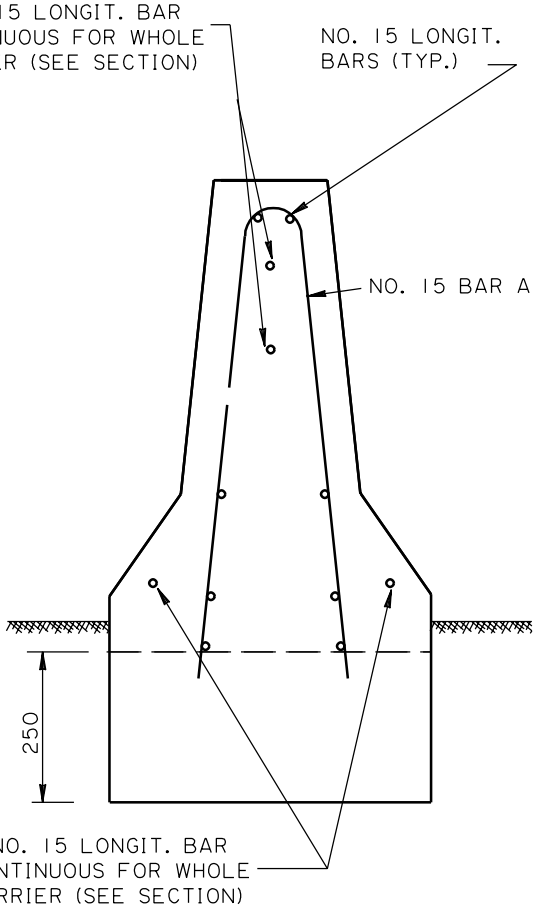
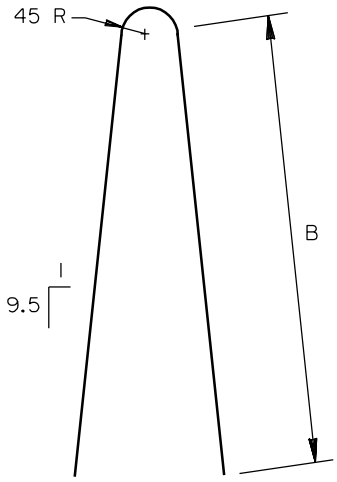


SECTION A-A



BAR A (NO. 15)

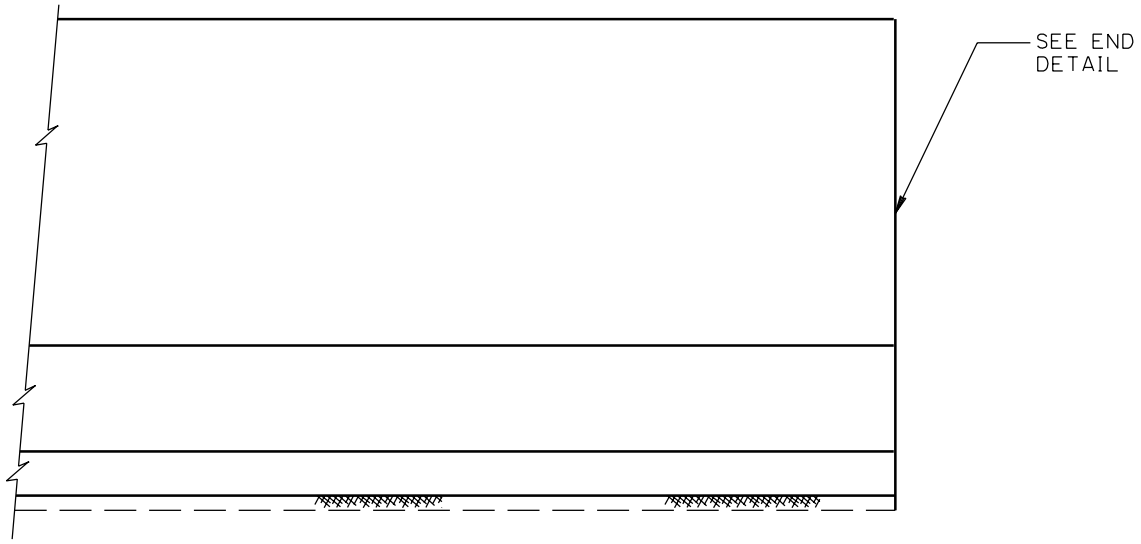
SYSTEM	B
N.J. SHAPE (PL-2)	910
N.J. SHAPE (PL-3)	1170

SAFETY-SHAPE MEDIAN BARRIER

2 OF 2

NOTES:

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THE BARRIER SHALL BE ANCHORED AT THE ENDS OR AT INTERRUPTIONS WITH EITHER A DOWELED-IN CONNECTION OR A 250 mm DEEP MONOLITHIC FOOTING.



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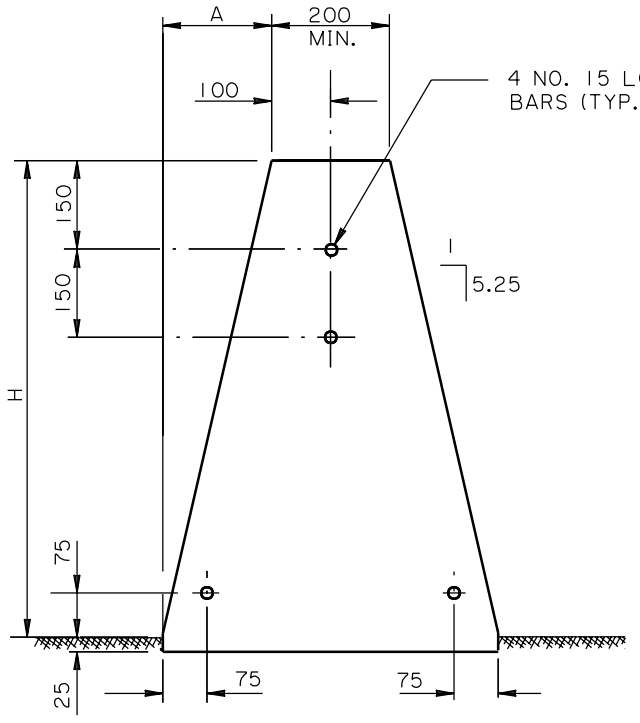

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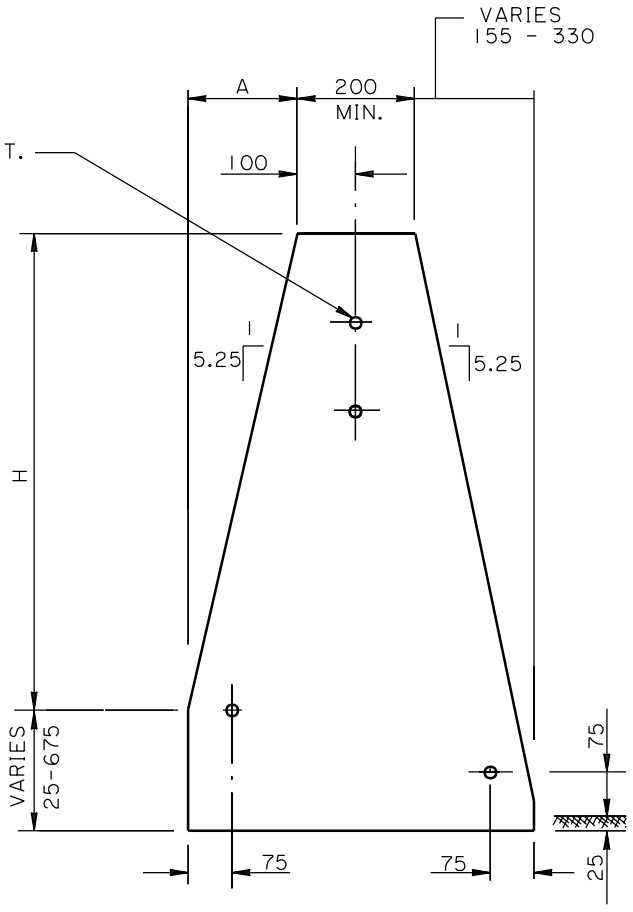


SECTION

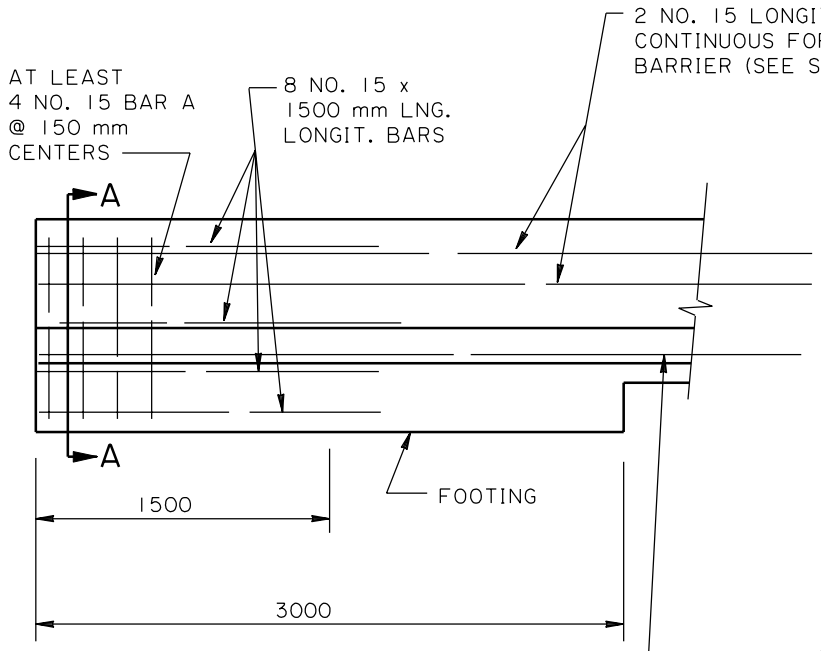
SYSTEM	A	H
SINGLE-FACE (PL-2)	155	810
SINGLE-FACE (PL-3)	205	1070

SINGLE-FACE MEDIAN BARRIER

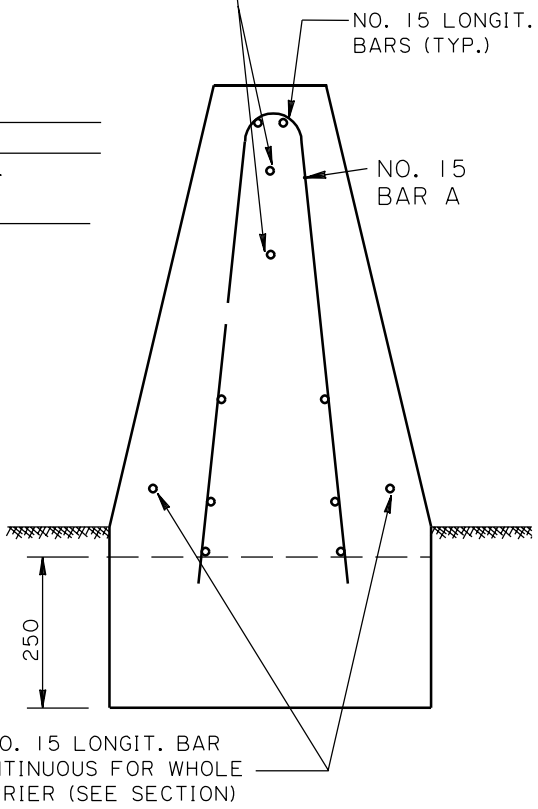
1 OF 2

NOTES:

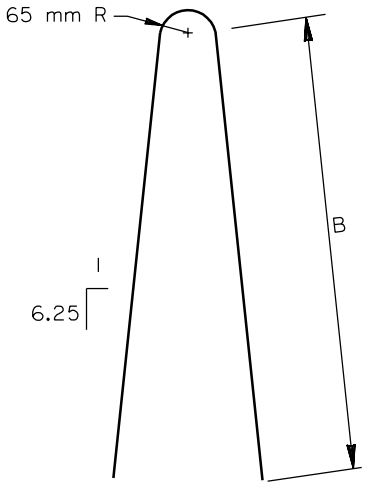
1. THE TOTAL LENGTH OF THE BARRIER SHALL BE LESS THAN 60 000 mm. A LENGTH OF 6 000 mm IS THE MOST COMMON.
2. BARRIER MAY BE MONOLITHIC WITH FOOTING OR IT MAY BE CONNECTED WITH 10 NO. 25 REBAR DOWELS SET 2 IN LINE AT 610 mm CENTERS.
3. USE MINIMUM COVER OF 40 mm.



ANCHORAGE DETAIL



SECTION A-A



BAR A (NO. 15)

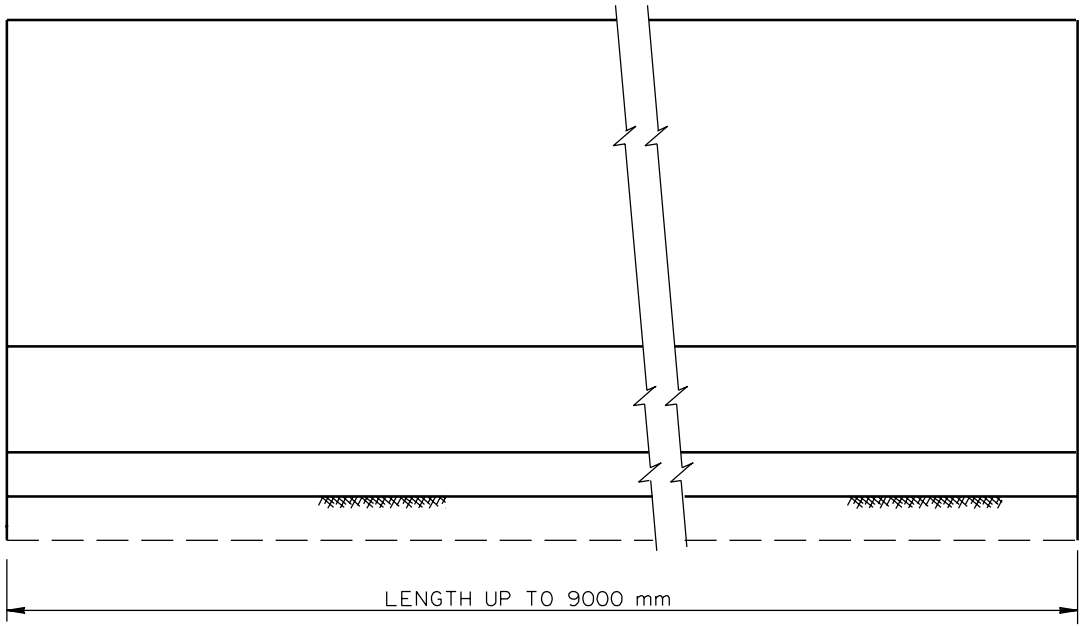
SYSTEM	B
SINGLE FACE (PL-2)	910
SINGLE FACE (PL-3)	1170

SINGLE-FACE MEDIAN BARRIER

2 OF 2

NOTES:

1. ALL EDGES SHALL BE ROUNDED WITH A 24 mm RADIUS EXCEPT AS SHOWN.
2. THIS BARRIER DOES USE REINFORCEMENT STEEL.
3. BARRIER RESTS DIRECTLY ON COMPACTED GRAVEL. 75 mm THICK PAVEMENT OR COMPACTED GRAVEL LAYER PROVIDES LATERAL SUPPORT TO THIS BARRIER.



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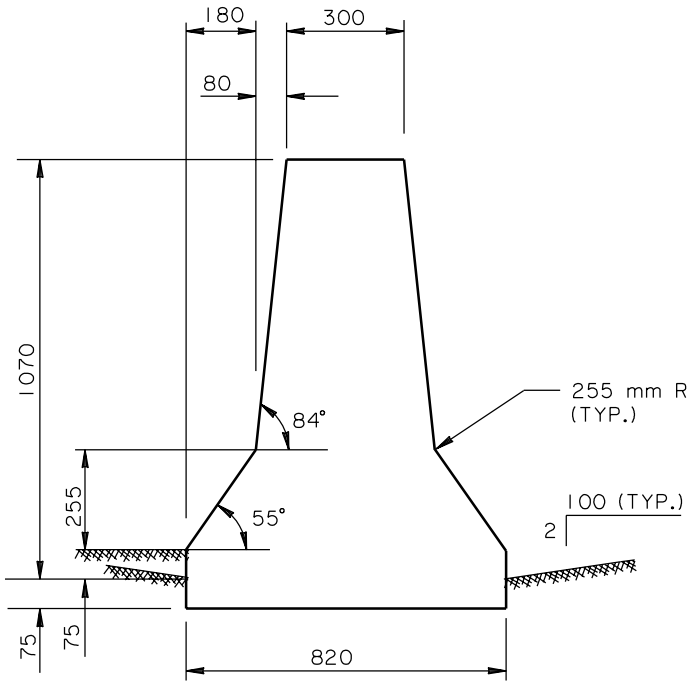
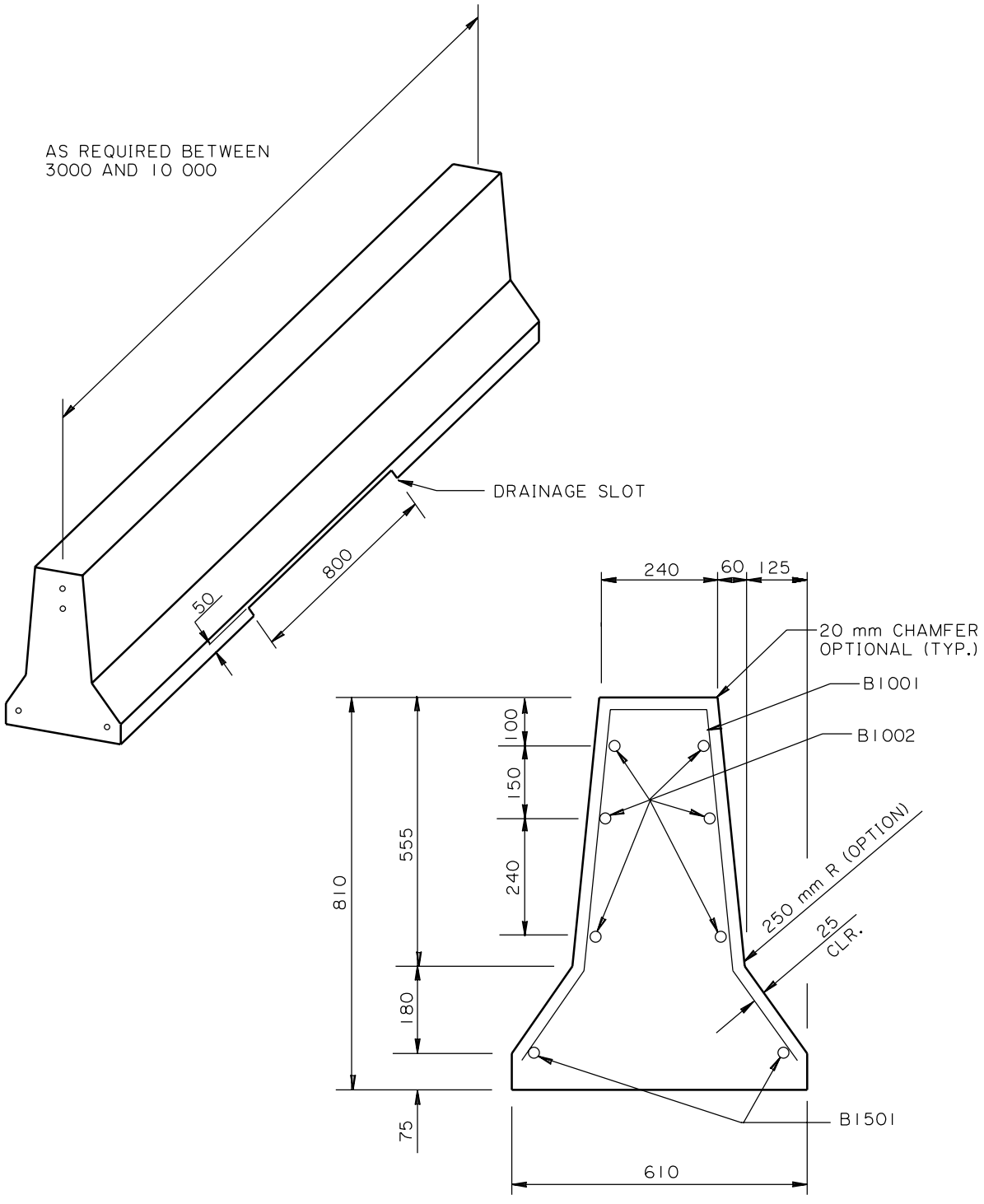


SECTION

TALL-WALL MEDIAN BARRIER

NOTE:

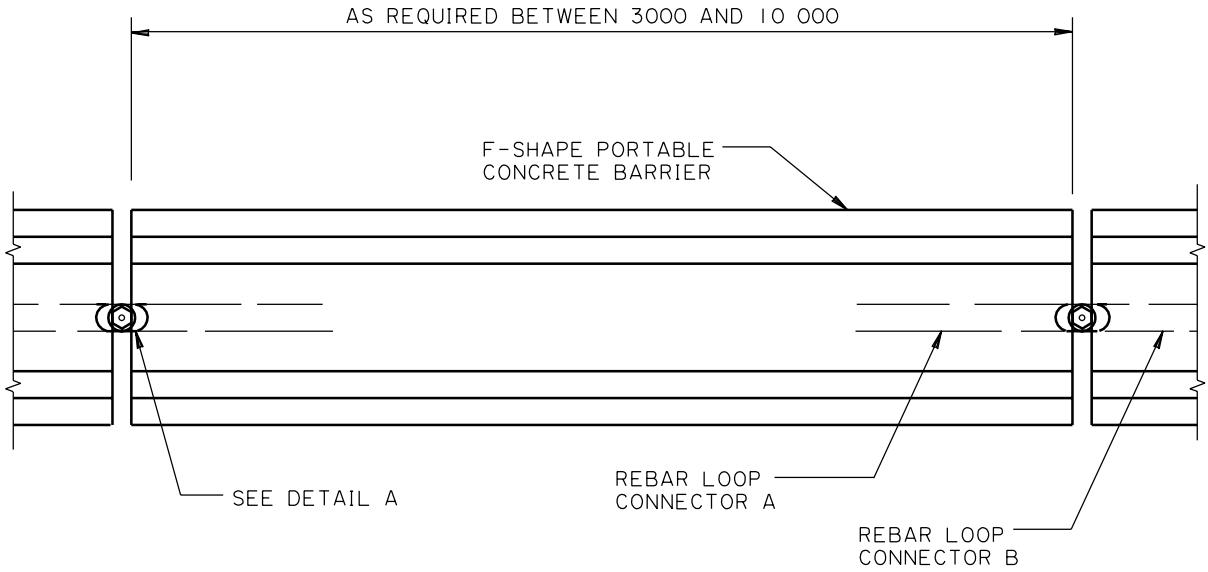
1. A CORNER RADIUS OF 25 mm IS PERMISSIBLE ON ALL EDGES UNLESS NOTED OTHERWISE.
2. EMBED A SUITABLE CONNECTOR INTO THE CONCRETE AT EACH END.



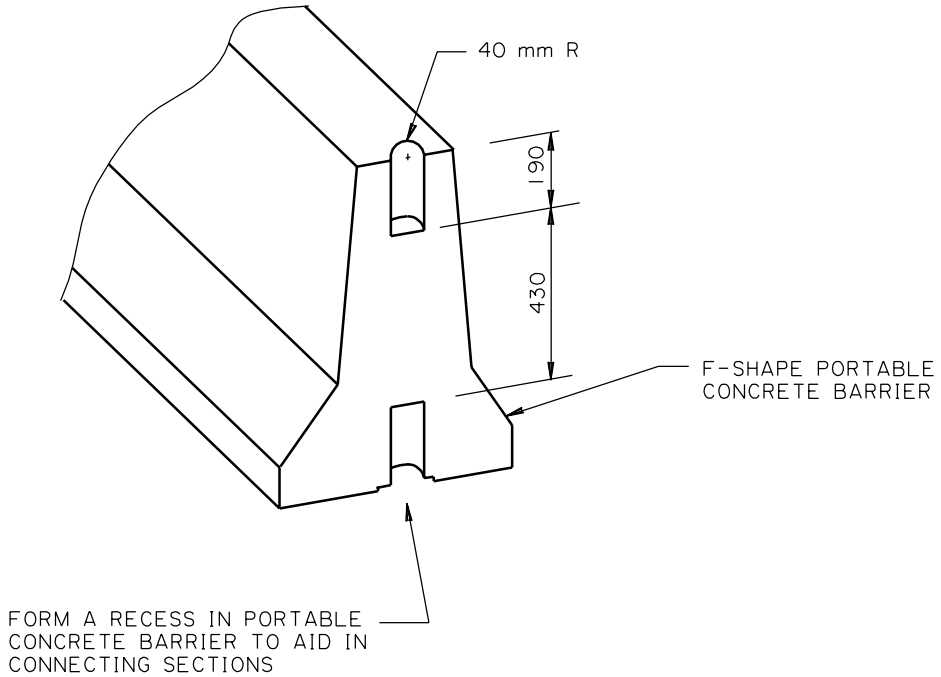
SECTION

F-SHAPE PORTABLE CONCRETE BARRIER

1 OF 4

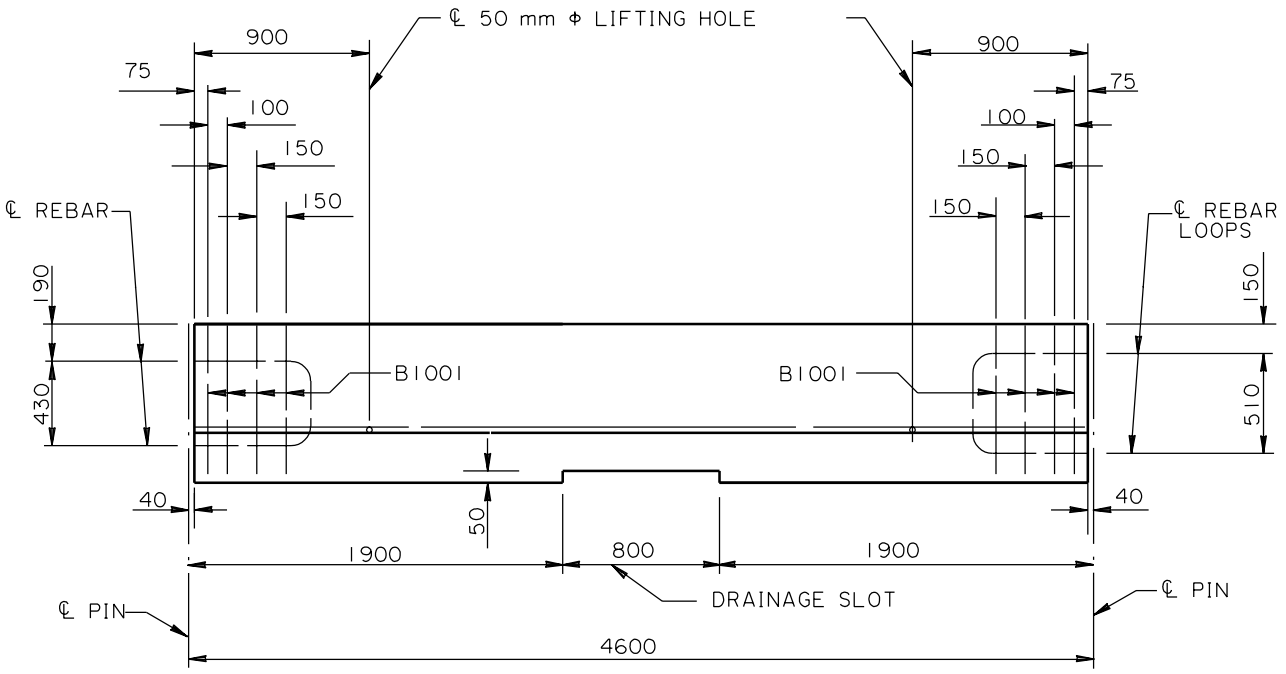


PLAN

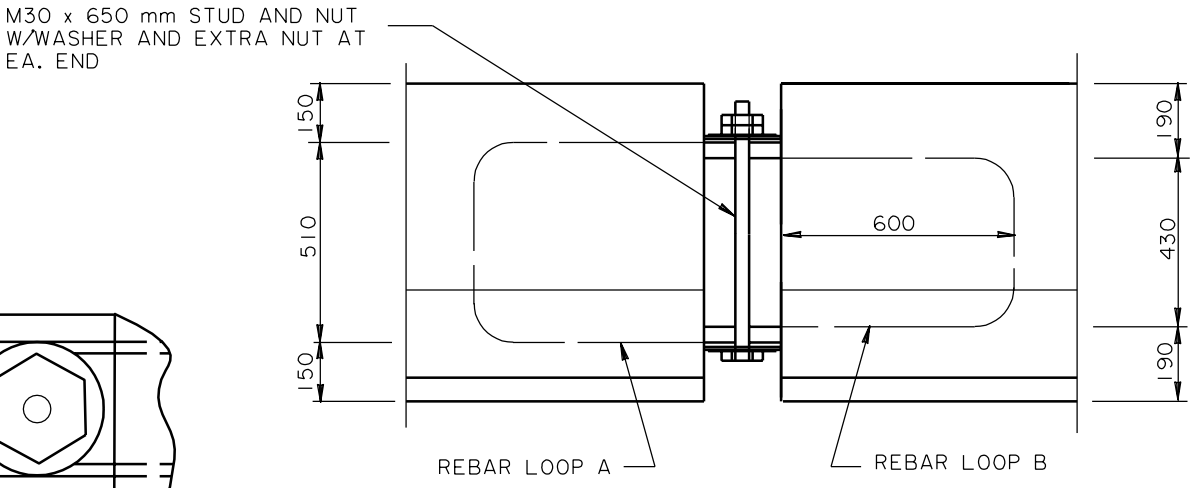


F-SHAPE PORTABLE CONCRETE BARRIER

2 OF 4

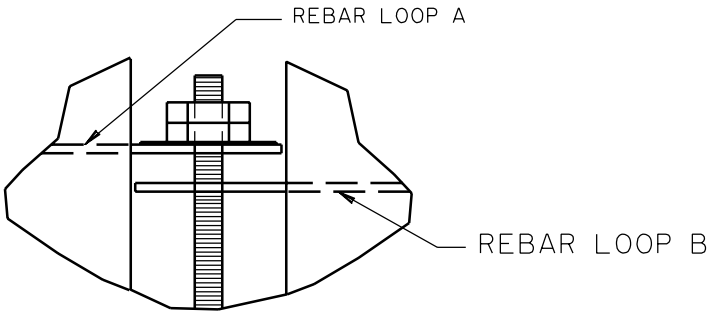


ELEVATION



PLAN

ELEVATION



ELEVATION

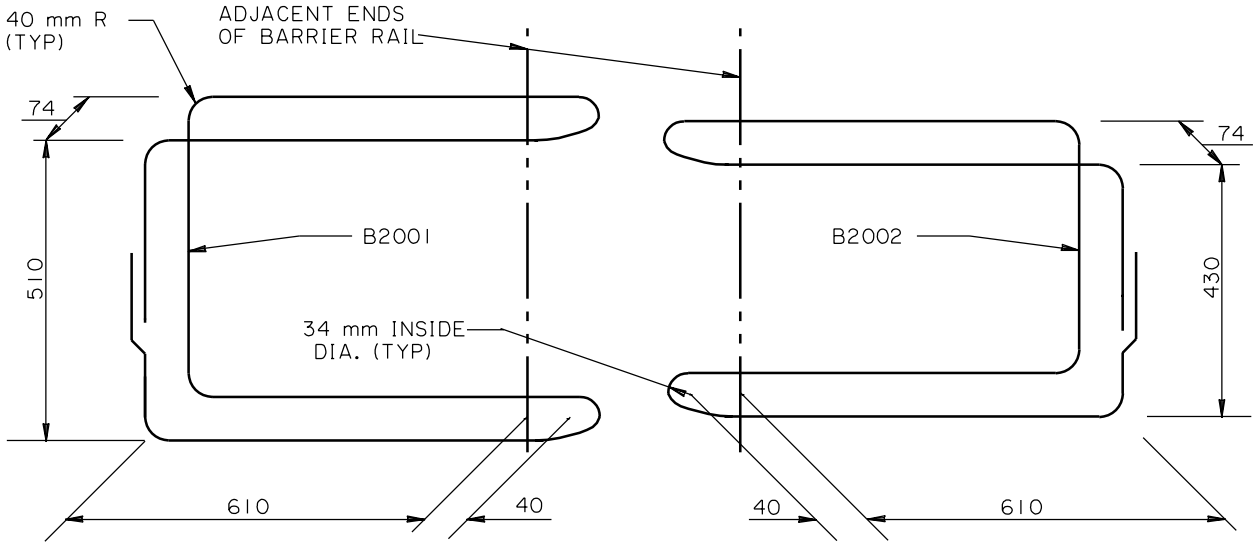
DETAIL A (CONNECTION)

F-SHAPE PORTABLE CONCRETE BARRIER

3 OF 4

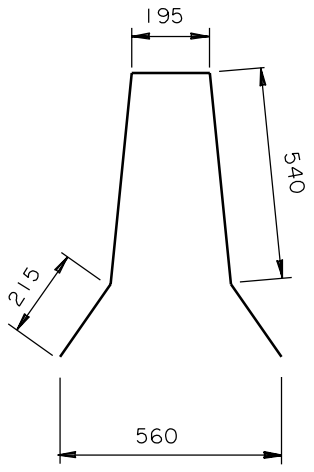
NOTES:

1. ALL REBAR DIMENSIONS ARE OUT-TO-OUT UNLESS NOTED OTHERWISE.
2. CONNECTOR MUST BE EMBEDDED INTO PORTABLE CONCRETE BARRIERS.



REBAR LOOP A
(ISOMETRIC)

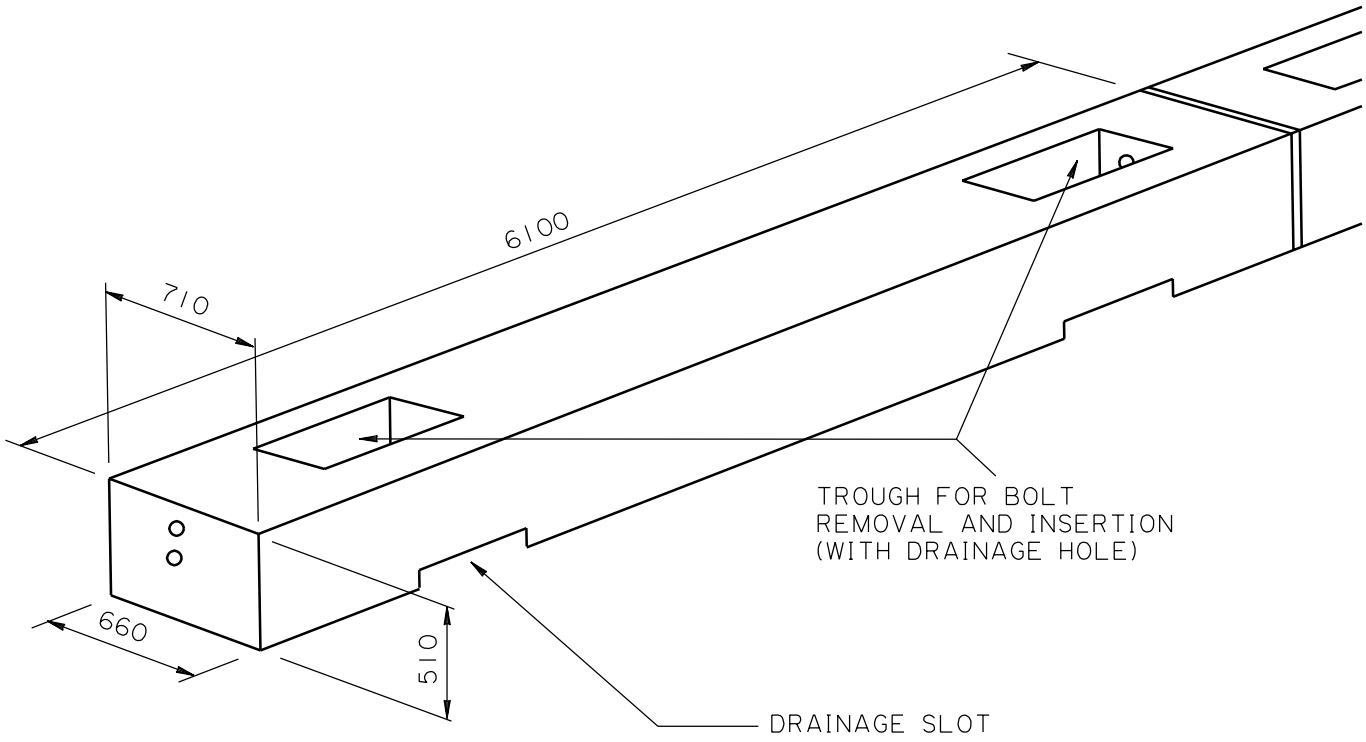
REBAR LOOP B
(ISOMETRIC)



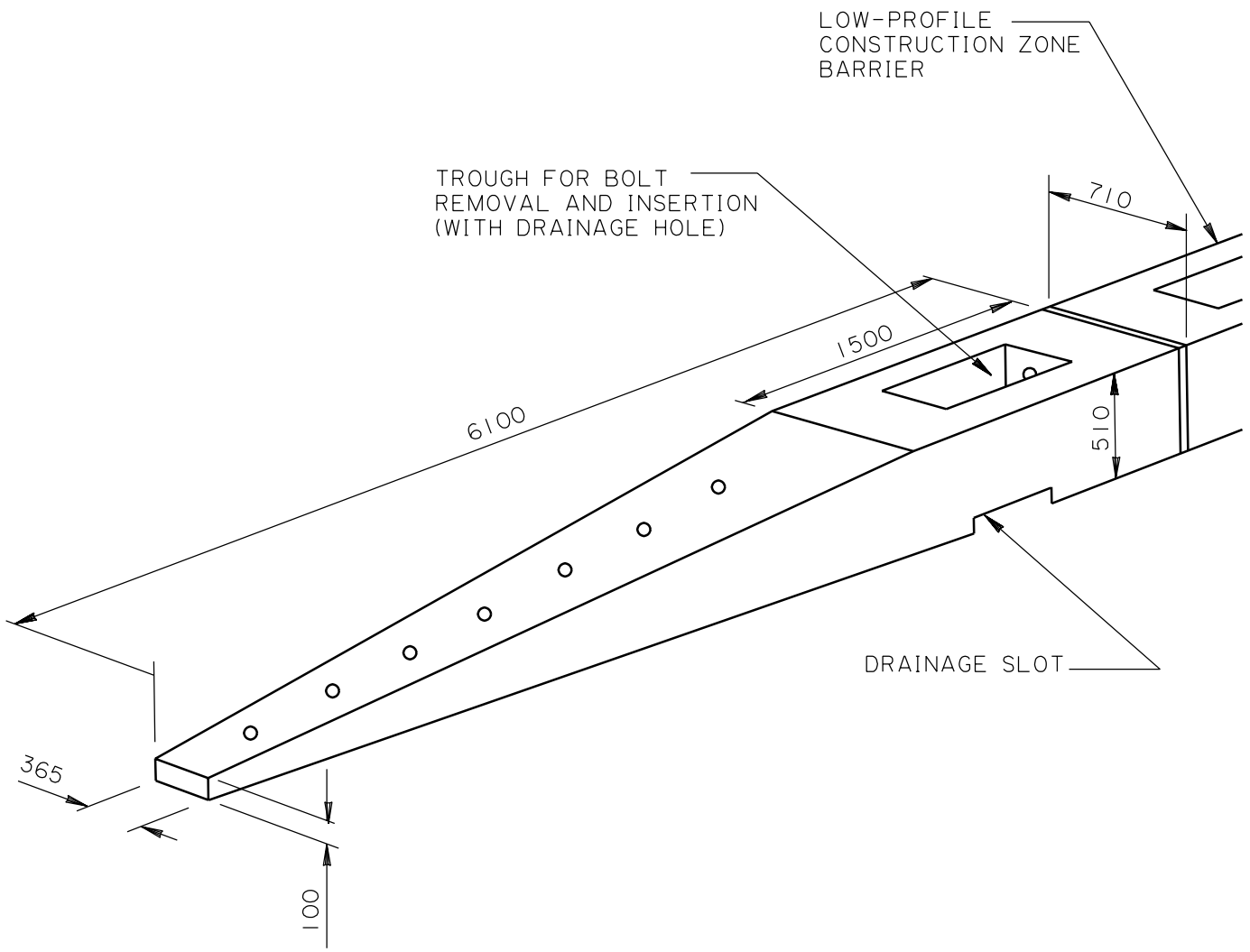
B1001

F-SHAPE PORTABLE CONCRETE BARRIER

4 OF 4



LOW-PROFILE CONSTRUCTION ZONE BARRIER



LOW-PROFILE CONSTRUCTION ZONE END TREATMENT